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Mapping the inventor new product development process

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Abstract: This paper seeks to build an understanding of how independent inventors navigate through their development programme and license their intellectual property (IP) rights to a business. While inventors are identified within open innovation literature as potential suppliers of externally generated IP their integration within the Open Innovation Model (OIM) is not adequately considered. This paper seeks to address this gap by presenting a validated model that describes the inventor IP in-licensing process.

The results of this inquiry suggest that successful inventors steer through a new product development (NPD) process that has structural similarities with the StageGate process deployed at an organisational level. Independent inventors are seen to be resource dependent and draw upon their personal resources and capabilities, supplemented by external resources, to navigate this process.

Keywords: New product development; innovation management; licensing; patents; inventors; open innovation.

In 2003, Henry Chesbrough published his seminal work on the concept of open innovation. Despite criticism that the concept offered little more than a re-branding of innovation management practice that had been occurring for at least forty years (Trott and Hartmann, 2009), the open innovation model (OIM) has captured the imagination of academics (van de Vrande et al., 2010) and the corporate world alike (Bughin et al., 2008).

The increased adoption of open innovation principles by businesses over the last decade does not appear to be contentious (Chesbrough and Brunswicker, 2014). Lichtenhaler (2011) highlights several academic articles (Beamish & Lupton, 2009; Cassiman & Veugelers, 2006; Teece, 1986; Von Hippel, 1988) that support the trend for businesses across industries to seek out and acquire, from external sources, technologies that complement their internal knowledge base. One external source of innovative inputs identified within OIM literature is independent inventors (Bughin et al., 2008; Lazzarotti et al., 2009). It is the integration of independent inventors as potential suppliers of IP to businesses through licensing that is the focus of this inquiry.

Smeilus et al., (2013) have previously argued that despite being identified as a possible external source of intellectual property (IP), independent inventors have received very little academic attention with regard to how they interact with businesses that operate an OIM. The aim of this paper is to provide a response to the following research question: how does an independent inventor navigate through their new product development programme and achieve a signed IP license?

For the purpose of this study an independent inventor is defined as: "An individual who creates new products, without formal obligation, outside of an established business." This definition is broadly comparable to those proposed by Lettl et al., (2009) and Weick and Martin (2006).

Development of a conceptual model

To develop a conceptual model transdisciplinary inputs were drawn upon. Specifically, the most salient points were extracted from ten theories identified through the literature review as being of potential importance and synthesized to create a conceptual model that addressed the research question.

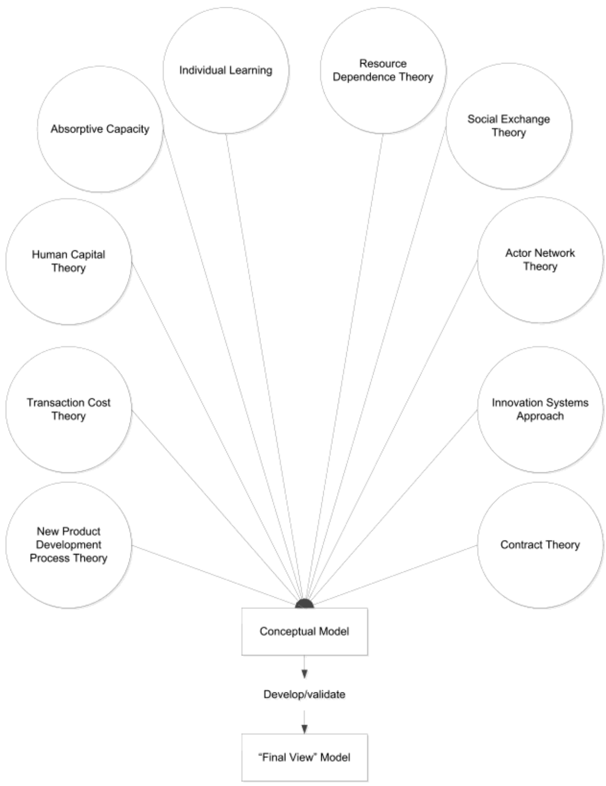


Figure 1 The synthesis of salient points from a variety of theories to create a conceptual model

An underlying NPD processes?

A presumption was made that some form of NPD process would form the centre-piece of an independent inventor's development programme. To establish a view as to whether such a presumption was accurate and what this process might look like, it was necessary to review both academic and non-academic literature.

A review of sixty-six successful inventor biographies presented by the Massachusetts Institute of Technology (MIT) as part of the Lemelson-MIT programme was performed. The purpose of this review process was to identify the type of development activity that inventors (although not specifically independent inventors) carried-out. It should be noted that these successful inventors did not necessarily use IP licensing as the method of commercialisation.

A number of useful insights into the development activities performed by successful inventors were identified. Most important was the view that there were development tasks that appeared repeatedly across the biographies studied. This suggested that an underlying NPD process was present. The development tasks typically performed included:

- The capture of inventive ideas by sketching conceptual designs

- The inventor performing internal screening of ideas to assess on-going viability.

- Conducting market research to validate elements of the invention and its possible market appeal

- The prototyping and testing of inventions

The conclusion drawn from the biographical review was that the development tasks performed by independent inventors have some commonality with those identified within organisational-level NPD process literature. On this basis, organisational-level NPD models were reviewed to inform the structure of the inventor NPD process within the conceptual model.

Academic literature relating to the NPD process is typically viewed in the context of there having been four distinct generations of NPD models. Each new generation departing further from the view that NPD is a linear and sequential process (Roussel *et al.*, 1991; Rothwell, 1994; Liyanage, Greenfield and Don, 1999; Millar, 2001; Chiesa, 2001; Berkhout and van der Duin, 2007). Berkhout and van der Duin (2007) provide a review of the key features of each of the four identified generations of NPD models.

Of the various NPD models reviewed (Maclaurin, 1953; Rogers, 1983; Berkhout, 2000; Schoen *et al.*, 2005), the updated Stage Gate Model (SGM) (Cooper, 2008) offers the greatest value when developing the foundations of a conceptual model that explains how independent inventors develop their inventions. The argument that the SGM is more useful than the other models is made on the basis that:

- The stages of activity identified within the biographical review of commercially successful inventors are broadly similar to those proposed within the SGM

- The SGM represents current thinking on the structure of the NPD process by acknowledging the iterative and cyclical nature of development activity

- The SGM provides detail concerning the types of development activity that might be found at each stage. Other models are less developed.

The Stage Gate Model

A key advantage of using the SGM to inform the conceptual model is that it incorporates detailed insight into the expected NPD activities and processes. The 2008 SGM is the culmination of research into organisational-level NPD conducted over two decades (Cooper, 2001; Cooper 2006a; Cooper 2006b; Cooper and Edgett, 2005; Cooper, Edgett and Klienschmidt, 1999; Cooper, Edgett and Klienschmidt, 2002a; Cooper, Edgett and Klienschmidt, 2002b). This detailed insight into which activities might be performed at each stage of the NPD process was important because it provides a robust starting point for establishing the types of development activity that might be found when developing inventions and licensing IP at an individual level.

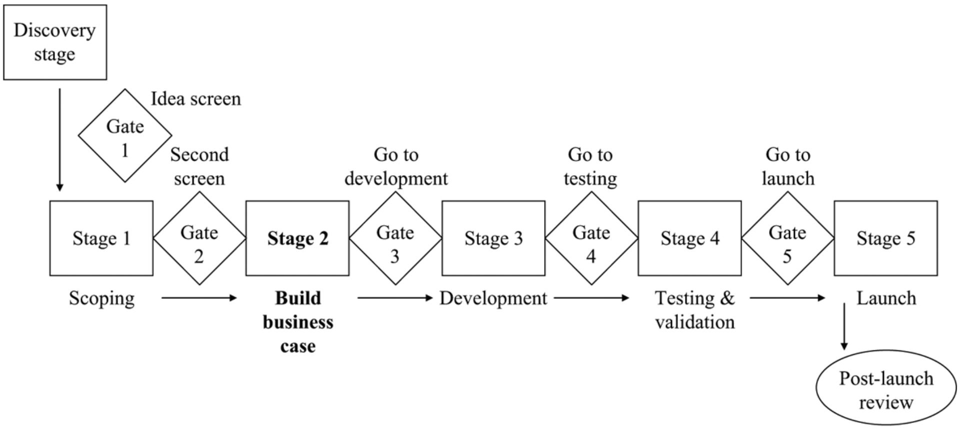
The SGM was initially described in Cooper (1990), although multiple revisions and additions have occurred up to and including Cooper (2014). The SGM is based upon a simple structure: activity stage followed by review gate. The idea is that each stage of development activity is assessed to evaluate whether the development programme is still viable. A development programme can be discontinued at any review gate within the process. Although the diagrammatic representation of the SGM depicts a linear and sequential process this is misleading. Within the SGM there is an expectation that each "Stage" contains iterative activity and feedback mechanisms (Cooper, 2008). Features of the SGM include:

- Stages and/or Gates can be skipped or omitted altogether, if they are not appropriate to the particular development project (invention)

- Parallel activity often occurs within each stage

- Gate assessments can see activity moved back a stage, if the desired outputs are not met.

- Activities within stages can be omitted or allocated to other stages, if required. (Cooper, 2008)



Source: Cooper (2008)

Figure 2 Stage Gate Model

While the SGM is useful in informing the foundation of the conceptual model, acknowledgment is made that the SGM is not entirely compatible with the requirements of this study (it is not specific to IP licensing). To this end a number of departures from the organisational-level SGM are required when specifying the conceptual model. The most significant departure relates to the "launch" stage. A traditional product "launch" via the developing company needed to be replaced by licensing specific activity. The following section details the act of IP licensing at an organisational-level with a view to proposing modifications to the SGM that make it relevant in the context of this inquiry.

Intellectual property licensing

With regard to the activities an independent inventor may need to perform in order to secure an IP license, the work of Lichtenthaler (2011) is particularly rich. Lichtenthaler (2011) outlines a three-stage process for undertaking the act of licensing:

Stage 1: Identification of potential licensees

Stage 2: Negotiation of specific terms with the potential licensee

Stage 3: Implementation of technology transfer

In a similar vein to the NPD literature, caution needs to be exercised when considering the three stages, in so much that they are proposed based on academic understanding of IP licensing at an organisational-level, rather than at the individual-level.

The licensing activities identified will be amalgamated with elements of the SGM to inform the NPD "process" element of the conceptual model.

How might the independent inventor navigate through the NPD process?

It is presumed that in order to navigate through the NPD process and achieve a signed IP license an inventor will draw upon their own personal resources and capabilities. These will be influenced by "Soft Qualities" such as their: personality, characteristics and attributes. "Hard Qualities" such as their human capital (qualifications and experience) may also prove important (Becker, 1964).

There are a number of theories that suggest that independent inventors are unlikely to navigate through the new product development process in a self-reliant and isolated way. In this respect, it is anticipated that independent inventors will display a degree of resource dependence (Pfeiffer & Salancik, 1978). Actor Network Theory (ANT) suggests that the existence of any technological or scientific artefact (inventions) should not be attributed exclusively to one individual, but viewed as the output of a network of "actants". An "actant" is defined as:

> "…something that acts or to which activity is granted by another…an actant can literally be anything provided it is granted to be the source of action" (Latour, 1996, p.373).

ANT suggests that it would be inappropriate to view the independent inventor as operating in isolation because an individual does not operate in a vacuum and is therefore subjected to influence from other actants in the wider environment.

> "The innovation process should be studied as a simultaneous development of an artefact and a network of actors connected to it." (Miettinen, 1999 p.170)

Actants within an actor network can be either human or non-human (Callon and Latour, 1981). This is referred to as generalised symmetry (Callon, 1986). Employing the notion of generalised symmetry, it is not only the human interactions the inventor undertakes that are important to the development and commercial exploitation of their invention. Interactions with non-humans (resources) must also be considered.

In order to create an actor network, linkages or "associations" must be formed between actants (Miettinen, 1999). The role of the independent inventor is therefore seen to be to enrol actants (that perform what are perceived to be important functions) into a network. In order to enrol actants an inventor must be able to effectively perform: "translations". A translation is:

> "…the process of making connections, of forging a passage between two domains, or simply as establishing communication." Brown (2002 p.3)

The process of translation is typically achieved through the use of: persuasive acts, negotiations and coercion.

ANT suggests that a significant challenge facing independent inventors is how to convince actants to participate in their network and how to govern the actants activity in a way that fulfils the requirements of the development programme (Latour, 1987).

The question arises as to where an independent inventor might enrol these human and non-human resources from in order to form a network that supports their efforts in developing an invention and realising licensing success. The Innovation Systems Approach (ISA) appears to provide a possible solution to this question.

An innovation system can be defined as:

> "…all important economic, social, political, organisational, institutional and other factors that influence the development, diffusion and use of innovations" (Edquist, 1997 p.14).

The ISA literature posits a non-linear and interdependent approach to innovation (Edquist, 2005) recognising that the NPD process may include phases of looped, iterative activity and that interaction between parties is both common and beneficial. Actors within an innovation system (including independent inventors) become connected via interactions.

Jacobsson et al., (2004) who provide one of the few empirical studies into innovation systems identifies five functions of an innovation system:

1. To generate new knowledge

2. To provide direction for search processes

3. To facilitate market formations

4. To supply resources

5. To assist in the creation of external economies

For the purpose of this research inquiry, the "supply of resources" and "direction for search processes" functions appear especially pertinent. This is because the independent inventor may seek to acquire important resources (human and non-human) for their development programme (forming an actor network), but can only achieve this aim if such resources exist and can be located within the innovation system.

How might inventors obtain externally hosted resources?

The process of enrolling an externally hosted resource into a development programme can be broken down into three stages:

1. Identification of the external resource.

2. Securing the external resource.

3. Deployment of the external resource within the development programme.

To identify the external resources required for their programme the inventor will be reliant upon the effectiveness of the innovation system (signposting function) and their own potential absorptive capacity (Zahra and George, 2002). The mechanisms used to capture these external resources are predicted by Social Exchange Theory (SET). Within SET it is suggested that resource acquisition can be achieved using social exchanges and/or economic transactions. Social exchanges include: negotiating assistance from family, friends or colleagues or seeking guidance from a knowledgeable individual (Homans, 1958; Blau, 1964; Emerson, 1976; Adler and Kwon, 2002; Chassagnon and Audran, 2011). This suggests that personal networks may also be a source of externally held resources. Economic transactions involve the inventor purchasing the required resources from an external provider (agent or organisation).

Upon acquiring the external resources required, the inventor needs to deploy them effectively with their development programme. Their capacity to do this is dependent upon their absorptive capacity – specifically their assimilation capability (Cohen and Levinthal, 1990; Zahra and George, 2002) and their individual learning capability (Ashworth et al., 2004). It is suggested that depending upon the nature of the resource acquired, the resource may be applied directly to the NPD process by the provider or indirectly applied by via the inventor.

Synthesizing the theoretical inputs into a conceptual model

By combining the SGM (Cooper, 2008) and the stages of activity identified as being important to the act of IP licensing (Lichtenthaler, 2011), a new modified stage gate model (MSGM) can be conceptualised. This NPD process can be embedded within a wider resource acquirement process that the inventor must go through in order to obtain the external resources needed to navigate successfully through the NPD process.

The proposed conceptual model suggests that the primary role of the independent inventor is to navigate through the NPD "process". A signed IP license should occur if the evidence produced within the NPD process meets the licensee's requirements. Close adherence to the MSGM is thought to be beneficial because it will encourage the production of evidence that demonstrates to potential licensees that development milestones have been satisfied.

In order to navigate through the NPD process (MSGM), the inventor will draw upon their personal resources and capabilities. It is thought that the inventor will not possess all of the resources and capabilities required to achieve successful passage through the MSGM. As a result, they can be considered to be resource dependent. The inventor has the option to overcome gaps in their personal resources and capabilities by acquiring additional resources from agents and organisations located within the external environment or within their personal networks. To identify the external resources required for their development programme the inventor will be reliant upon the effectiveness of the innovation system (signposting function) and their own potential absorptive capacity (Zahra and George, 2002). It is predicted that the acquisition of external resources and capabilities will be achieved by the inventor using social exchanges and/or economic transactions.

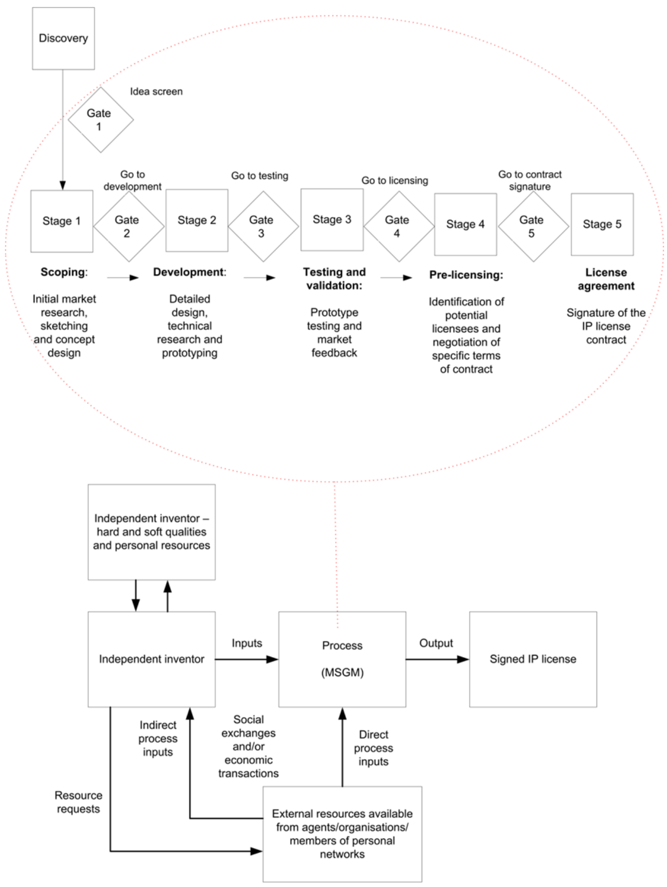


Figure 6 The conceptual model

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The conceptual model was tested through a programme of fieldwork. This fieldwork is outlined in the following section.

Research design

A two-stage, mixed methods research design was employed. The provisional stage involved collecting data from independent inventors regarding their thoughts and experiences in the domain of new product development and IP licensing. The research methods utilised within the provisional stage were: a quantitative survey of 202 independent inventors and four case studies with independent inventors who have engaged with IP licensing. Each of these elements is now discussed further.

The questionnaire was made accessible to independent inventors in both online and paper based formats. The survey was restricted to UK residents and limited to independent inventors as defined previously in this paper.

The dependent variable (DV) for the quantitative survey was the level of IP licensing success achieved by the inventor. The DV was a binary variable:

1. The independent inventor has achieved IP licensing success
2. The independent inventor has attempted to licence their IP, but as yet remains unsuccessful.

A concern when conducting the quantitative survey element of this research inquiry was the extent to which non-response bias (Denzin 1989; Lohr, 1999) might affect the validity and reliability of the research. There was acknowledgement at an early stage in this research inquiry that identifying independent inventors within the wider UK population would be challenging because they are essentially a hidden-population. The difficulty in identifying independent inventors meant that survey invitations were initially issued to independent inventors who had previously approached an organisation that provided some form of inventor support. This course of action had the potential to exclude independent inventors who did not collaborate with support organisations and preferred instead to work in relative isolation. To alleviate some of the potential for non-response bias a snowball sampling approach was used whereby independent inventors who were initially approached to participate in the survey were asked to forward details of other inventors they knew, so that further invitations to participate could be issued. This provided inventors who had not previously engaged with a support organisation the opportunity to participate in the survey.

The case studies were descriptive and embedded in nature (Yin, 1994) and focussed upon detailing NPD development activities and the scheduling of these activities. The selection of four cases is consistent with Eisenhardt's (1989) view of the optimal number of cases needed for theory building through case study research (four to ten cases). The choice to pursue multiple case studies was purely to allow replication to be achieved. Replication allows the findings of the first case study to be corroborated and/or extended by additional cases (Yin, 1994). The use of four cases enabled two successful cases and two unsuccessful cases to be analysed. First, literal replication logic was applied (Yin, 1994). A successful inventor case was replicated with another successful case with the expectation that similar and predictable results would be achieved. The same process occurred for the unsuccessful cases. Next, theoretical replication logic (Yin, 1994) was applied. The two successful case studies were compared to the two unsuccessful cases with the expectation that predictable and contradictory results would be obtained.

The case studies were based upon two inputs: first, semi-structured interviews with the independent inventors and second, content analysis of documentary secondary evidence relating to the case. Content analysis was performed in accordance with the procedure outlined by Krippendorff (1980).

Following the initial data collection and a preliminary analysis phase, an intermediate view of the phenomenon under examination was produced. This intermediate view represented the initial interpretation of how independent inventors navigate through the NPD process and achieve a signed IP license.

The second stage of the research design was used to validate the intermediate view by subjecting it to review by key informants. The Key Informant Interviews were intensive, semi-structured interviews based on a series of interview prompts. Each interview lasted approximately thirty minutes. Key informants were chosen using the criteria set-out by Tremblay (1957). The key informant inputs were used to both confirm elements of the intermediate view and to revise this view where necessary. The validation stage resulted in the production of a final view that provides an explanation of the phenomenon under investigation.

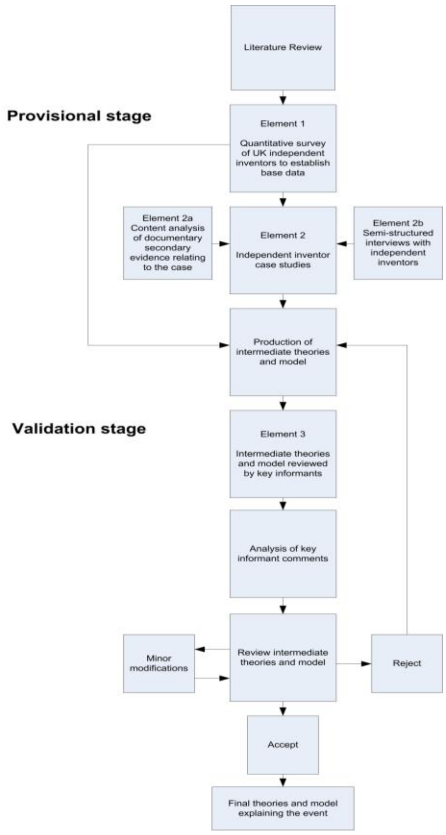

Figure 7 The research design

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Findings

The results of the fieldwork provide support for the conceptual model however extensions to this preliminary view can be made.

It was found that inventors steer through an NPD process that contains a series of development activity stages and review gates. The structure and scheduling of the inventor NPD process is similar to that proposed within the conceptual model. The validated inventor NPD "process" is summarised in Figure 8. The perforated line defines the scope of this inquiry.

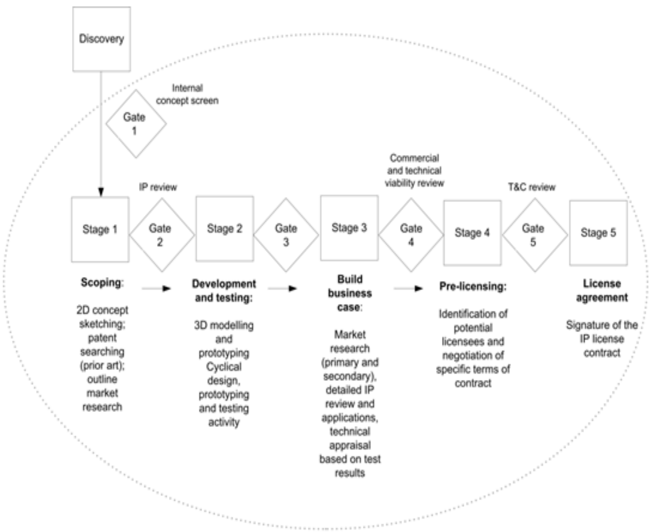

Figure 8 Inventor NPD process specific to IP licensing

Based upon a comparison between the successful inventor NPD processes and the conceptualised MSGM (Figure 3.3) the following differences are noted:

1. The predicted "Ideas Screen" within the MSGM is replaced by an "Internal Concept Screen" that is less formal and more subjective than anticipated. This screen draws heavily upon the inventor's hard and soft qualities to bring about a judgement on the merits of a given invention.
2. The "Scoping" stage of activity places greater emphasis on IP considerations than predicted in the conceptual model. While 2D sketching and initial market research did occur at this stage, successful inventors were more concerned with establishing the potential patentability of their respective inventions by undertaking a review of prior art and seeking expert input on protectable features.
3. An IP review gate was included by successful inventors at an early stage in the process. The intention was that any invention that could not be protected in a meaningful way is discarded before further resources are committed to the programme. Since the patent is the exchanged asset in the context of this inquiry, the capacity to achieve patent protection is of paramount importance.

4. The conceptual MSGM suggests that inventors will pay little attention to developing the business case for the invention, however this was not found to be accurate. The successful inventors studied did incorporate a specific "build business case" stage within their NPD process.
5. Rather than two separate stages of activity: "development" and "testing", the fieldwork revealed that a single, but cyclical "development and testing" stage is more appropriate.
6. While much attention was given to the sequencing of activity in the MSGM, the order in which the "build business case" and "development and testing" activity was performed by inventors does not seem to impact upon the outcome of the process. This observation is made with the caveat that a "scoping" stage where consideration is given to the basic commercial and technical case for the invention has been performed previously.
7. The "pre-licensing" and "license agreement" stages were evident within the case studies, as predicted in the MSGM. These stages are separated by a "terms and conditions" review gate where the inventor makes an assessment as to the acceptability of the proposed terms and conditions of the IP license agreement.

In order to navigate through the NPD process effectively, inventors draw upon their soft qualities, hard qualities and personal resources. Inventors appear to be resource dependent (by choice or necessity) and so they also seek out resources held within the external environment to assist them in circumventing obstacles they encounter (This task is a function of the inventor's potential absorptive capacity.) These external resources are controlled by either: agents/organisations within the innovation system or members of the inventor's personal networks. Both social exchanges and economic transactions are used by the inventor to acquire externally controlled resources. The ratio of social exchanges to economic transactions gives rise to a "mode of resource acquisition". Neutral, social-exchange biased and economic-transaction biased modes of resource acquisition are possible. Inventors may have a preference for one "mode of resource acquisition" over another; however it is likely that the inventor's personal context (hard qualities, soft qualities and personal resources) will make certain modes more appropriate than others. For instance, an inventor with low-levels of personal financial resource may be pushed towards a social-exchange biased mode of resource acquisition because economic transactions are not financially viable. The ability to deploy external resources effectively within the NPD process is seen to be a function of the inventor's assimilation capability and individual learning capacity. The interconnected nature of the resource acquisition element of the development programme (whereby the inventor interacts with agents, organisations and members of their personal networks with the purpose of resource acquisition) is summarised in Figure 9.

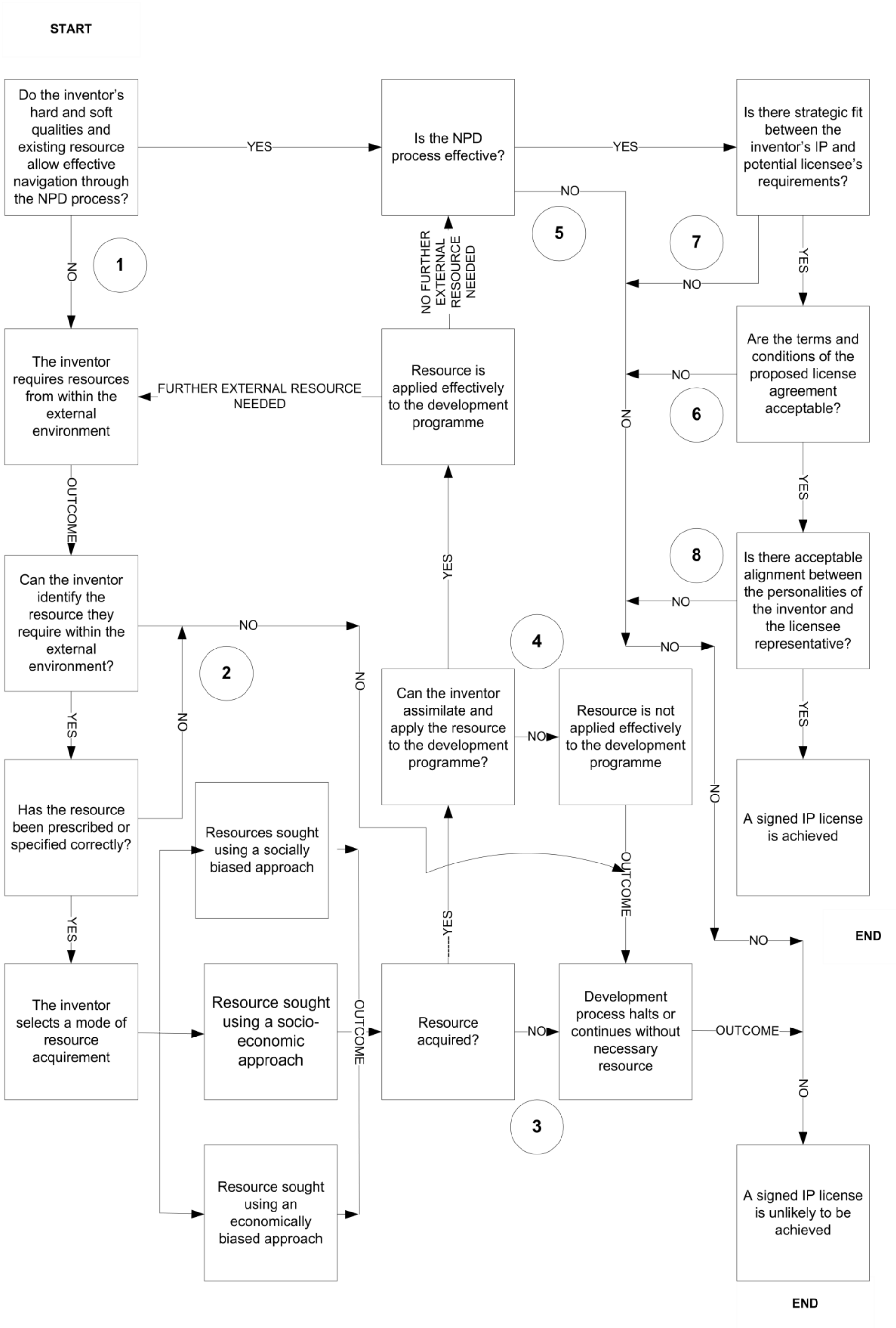

Figure 9 Flowchart describing how independent inventors realise a signed IP license and the obstacles faced

It was found that inventors are likely to encounter a number of obstacles when attempting to navigate through their development programme. The principal obstacles are summarised in Table 2. The point at which these obstacles are typically encountered by inventors within the development programme is described in Figure 9. The reference number for each obstacle is contained in column three of Table 2.

Table 2 Obstacles encountered by inventors and the impact of these obstacles

Obstacles	***Impact***	***Reference in Figure 9***
The inventor possesses insufficient personal resources and capabilities to navigate through the NPD process effectively.	The inventor either: abandons the development programme, continues in an ineffective way or is forced to seek external resources.	1
The inventor is unable to identify or correctly specify the external resources that will enable successful navigation of the NPD process.	The obstacles the inventor faces within the NPD process are not overcome because the resources required cannot be located or do not solve the challenge faced. The programme may proceed in an ineffective way or be abandoned.	2
The inventor fails to secure the external resources they require to proceed successfully through the NPD process.	The NPD process is abandoned or the process continues with fundamental problems present. Licensing success is unlikely.	3
The inventor is unable to assimilate, absorb and deploy the acquired resources to the NPD process.	Resource acquirement proves futile. The acquired resource is not applied to the NPD process in an effective way. Challenges in the NPD process are not overcome. The process is abandoned or becomes ineffective. Licensing success is unlikely.	4
The NPD process is ineffective.	The process fails to generate evidence of the required quality to satisfy potential licensees. The project is viewed as too risky and an IP license is not achieved.	5
The inventor is unable to negotiate acceptable terms and conditions for the IP license contract.	The IP license contract will not be agreed between the parties. Licensing attempts fail.	6
There is a poor "strategic fit" between the inventor's IP and the potential licensee's requirements.	The licensee does not require the IP being offered. Alternative licensees need to be identified. The development programme may be abandoned.	7

There is a mismatch between the inventor's personality and that of the licensee.	The proposed licence contract is unlikely to be agreed because the post-contract transfer of knowledge is likely to prove problematic. The potential licensee perceives the licensing opportunity to be too risky.	8

Contribution to theory

This inquiry enhances current theory on the in-licensing element of the OIM. The inquiry is focused specifically on detailing the process undertaken by independent inventors when licensing their IP to a business. Current academic literature does not consider independent inventors as an external innovation partner in this context and so this contribution is novel. Two distinct contributions to theory are made within this paper: first, a conceptual model that describes how an independent inventor navigates through their development programme and achieves an IP license is presented. This initial model was formulated by extracting the salient points from ten transdisciplinary theories and synthesizing the outputs to form a conceptualisation of the process. This model represents the first time that the inventor licensing process has been mapped and provides a theoretical foundation that underpins the in-licensing activity described in the OIM.

Having developed the conceptual model, a programme of fieldwork was undertaken to develop and validate it. The output of this fieldwork was a "Final View" model that demonstrates high-levels of internal and external validity. The "Final View" is the second contribution to theory produced as a result of this inquiry. The model is unique and makes a genuine contribution to theory in this field. The view is taken that the "Final View" model strengthens the in-licensing element of the OIM by detailing the inventor NPD/IP in-licensing process and the potential obstacles faced by inventors.

Contribution to practice

The government is seeking to drive forward the economic performance of the UK by encouraging businesses to innovate. One way in which businesses may improve their innovative performance is by internalising and then commercialising the IP generated by external parties. Independent inventors are an under-utilised source of IP from which businesses could leverage greater value.

The view pursued within this research inquiry is that independent inventors could make a more valuable contribution to the innovative performance of UK businesses (and in turn improve the UK's economic performance) by becoming effective suppliers of IP through the in-licensing mechanism. This necessitates developing a better understanding of the process so that it can be made to work more effectively. This inquiry provides valuable insight into the inventor IP licensing process that enables OI professionals to manage the interface between business and independent inventors more effectively.

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